II. — Geographical and Geological Surveys.

I. GEOGRAPHICAL.

There was perhaps never a time when so much general interest was felt in geographical work as at the present. Geography is decidedly the fashionable science; that is to say, not exactly geography, but geographical exploration, or, in other words, the investigation of the yet unknown portions of the earth. All the European nations are vying with each other as to which shall be the lucky country to secure the honor of being the first to solve some one of the few great geographical problems which yet remain to be worked out. England soon starts her expedition to the farthest North, roused to action in this direction, after many years of waiting, by the successes of the Americans, the Swedes, and the Austrians. The Germans themselves are attacking the one great question which Africa has yet to offer, namely, the tracing of the mighty Congo River to its source; while an Englishman is also struggling — unless he has already succumbed to some one of the many dangers of African exploration — to follow the connection of the lakes about which Livingstone's last work was done, and which he believed to be the head of the Nile, but which are now known, almost to a certainty, to belong to the hydrographical basin of the Congo.

Geographical societies and journals were never more numerous in Europe, or more fully patronized, than they now are; geographical papers find their way into the quarterlies and monthly literary magazines; and the sale of photographs of scenery is rapidly increasing, and tending powerfully to develop an interest in all peculiar features of the earth's surface, and thus leading to the study of comparative geography. All along the base of the great European chain of mountains, the Alps, and on both sides of it, clubs have been formed for the purpose of uniting the means and energies of the many in the work of exploring the unvisited portions of the range, and of thoroughly working out the details of that which is as yet only partially known. These clubs number their members by the

hundreds, and their published volumes already form a goodly series.

But while all this and much more of the same kind is being done, indicating a lively interest on the part of the general public in those explorations which have, as the result to be attained, some brilliant discovery, or the settlement of some long-discussed problem, there is, at the same time, another class of geographical work always in progress and on a vastly greater scale and of vastly greater importance than that of mere exploration, but in regard to which the general public knows almost nothing, and to which the popular magazines hardly ever allude. We refer, of course, to the great topographical surveys which are being carried on in every civilized country in the world, almost without exception, and which have for their object the preparation of topographical maps of the regions surveyed. Such maps have as their essential features absolute accuracy and minuteness of detail; and in this respect they contrast strongly with the work of preliminary exploration, or of reconnoissance, as this sort of surveying is commonly called. By the work of a preliminary reconnoissance, the character of the dominant physical features of a previously unknown region is ascertained, a laudable curiosity satisfied, and the nature of certain great commercial problems indicated. The topographical survey, on the other hand, presupposes a country already settled, and having made considerable progress in civilization, art, and commerce, so that land has acquired a high value, thus rendering accuracy in the determination of its subdivisions a matter of pecuniary importance. The object of the writer of this paper is, to explain in a popular way, without the use of any more technical terms than are absolutely necessary, the difference between geographical exploration, or reconnoissances, and topographical surveys, and also to show what the latter are intended for, and what other civilized nations are doing in this line. It will then be interesting to inquire what the United States, either in their collective capacity or singly, have been able to accomplish towards a complete mapping of their own territory, and to give some hints as to what yet remains for us to do, that we may be put on a par with other countries with which we are much

in the habit of considering ourselves, if not a little superior, at least fully equal in point of general intellectual development. The recent discussion of this subject in the Legislature of the State of Massachusetts has very clearly brought out the fact that, in regard to the value and cost of a topographical survey, or, in other words, of a correct map, our law-makers and a good part of the general public are very much in the dark; and it is hoped that a careful setting forth of some of the principal facts, by one who has had considerable experience in this sort of work, under United States and State authority, may be of interest, and perhaps useful when the subject is again brought up for discussion.

Let us first consider in what way the surface of the earth may be delineated, so that the result may be available for use. Almost every one, even the youngest school-boy, has some general idea of what a map is, and how by certain conventional signs it is the aim of the map-maker to place before the eye a miniature representation of some portion of the earth's surface, so that the relative position of its natural features, and of the artificial constructions or lines drawn upon it, may be taken in at a glance. These natural features are rivers, lakes, oceans, mountains; the artificial constructions are streets, roads, buildings, railroads, canals, and the like; the artificial lines which need to be indicated are the boundaries between States and towns, and other similar subdivisions of public and private property. That the above-mentioned features can easily be indicated on a map by lines, when their position has been carefully ascertained by instrumental measurements, is not difficult to understand; but there is another important element which needs representation, but which can at best only be approximately shown, and in regard to the best method of doing which there is no clearly established opinion. This element is the vertical, or the relative elevation of different portions of the surface, which we know exactly whenever we can ascertain the precise height of every point above some fixed datum line, and which can also be approximately indicated by conventional symbols, as will shortly be explained. As this is an important question in topographical surveys, and one not well understood by the general public, some little detail in regard to it may be acceptable.

The most accurate and, in some respects, the most satisfactory way of representing the surface of any region is, to make a model of it; that is, a copy, in relief, necessarily on a greatly diminished scale, by which all the natural features, including the vertical element, are represented. Such models are usually first worked out in clay, just as a statue is copied by a sculptor from a living model, and then cast in plaster; or it may be carved in wood, or cut in cork, or made by piling sheets of cardboard cut into the proper shape upon each other. The data for such models must, of course, be obtained by measurements on the earth's surface, just as they would have to be if a map were to be made. These topographical models are particularly interesting and valuable when they include regions covered by lofty and precipitous mountains; and such have been made for parts of Switzerland which are visited by great crowds of pleasure-travellers. One, in particular, at Geneva, is wonderful in its execution, and is studied with the greatest interest by thousands who have climbed or tarried with delight under the shadow of the "monarch of mountains." Such models, however, are not only extremely costly, but they are, as may well be imagined, very cumbrous and entirely unsuited for transportation; neither can they be duplicated without great cost, unless limited to very small areas and made on a small scale. Hence they are rarely used, unless in peculiar and exceptional cases. Thus, for instance, in laying out a park for a large city, where the work is all to be done at once, and where the amount of money to be expended is very great in proportion to the area of ground used, and where the vertical element is of great importance, a model may often be of great assistance and indeed almost indispensable.

A photograph from a model gives, if taken with skill, under a suitable illumination, a wonderfully clear idea of the relief of the surface. One such, of the vicinity of Mont Blanc, done by a French artist, on a scale of 1 : 80,000, lies before us, and nothing can be more satisfactory than the way in which the form of the surface is brought out by it, so that the eye can appreciate, at a glance, the exact relative position and elevation of the different parts of that great mountain mass. There are obvious reasons, however, why such models and photographs

from models cannot come into general use. They are too expensive and not sufficiently portable, — portability being a very essential element in the use of geographical material. They are well adapted, however, for many purposes in teaching, and especially for conveying the first general idea of forms of surface to the young; they are also invaluable for illustrating geological structure in difficult and complicated regions.

Paper is the material on which the topography of a country is usually exhibited; and maps drawn upon paper, or else engraved or lithographed and then printed on that material, are in almost universal use. Hence a map means a representation on paper of some part of the earth's surface. It is easy to see that the first question to be asked in constructing a map is, What shall be its scale? or, What proportion shall it bear to nature? The school-boy's map of a hemisphere can hardly be more than a hundred-millionth of the natural size of the part of the earth which it covers, since it must show half the world on one small piece of paper; while the British Ordnance Survey map of the city of London is on a scale of one-thousandth, and occupies no less than 821 sheets. The former hardly does more than roughly indicate the boundaries of a continent, and of the principal states into which it is divided; while the latter exhibits the exact form and position of every building and division line of the land in the city. It will be easily understood that, in order that small objects may find room on which to be represented, a large scale must be adopted. It will also be not difficult to perceive that, in order to be able to prepare a map on a large scale, the preliminary topographical work must have been done with a proportionate degree of accuracy and minuteness of detail. The amount of time and money which has to be expended on a work of this kind is proportionate to the amount of information it is intended to exhibit, and that this expenditure should be proportional to the importance of the area to be surveyed, that is, to its wealth and the density of its population, seems evident; and this would lead us to infer that the mostly thickly settled and richest countries must have the most accurate maps. This, however, is not uniformly the case; the general intelligence of the people, or their rulers, their habits of thought, and their appreciation

of the practical use to which scientifically accurate work may be put, are also important factors, as will perhaps be discovered from what is said further on in these pages.

The determination of the scale to be adopted in any topographical survey means, then, the determination of the accuracy with which it is to be conducted, or the amount of detail to be put into the work. And it does not appear difficult to understand that, in a large country or state, it may be advisable to employ several different scales, or to proportion the accuracy of the survey to the importance of any separate division. A country like Belgium, of very small area, and with a population about equally distributed over its surface, would naturally be satisfied with much less variety of scale than would be advisable in Norway or Sweden, some portions of whose territory are very thinly inhabited. The same considerations would apply still more forcibly to our own country, great areas of which are almost worthless, or at best of no importance, except as having to be passed over in order to get in the shortest way from one part to another of our extended territory. It is true, however, that the same country usually requires maps on more than one scale, even if the survey is to be equally accurate over the whole area. For local details and for ordinary practical use, a map on a large scale is needed; but this requires that the work shall occupy a great number of sheets, on each of which only a small area can be given; so that, for general geographical purposes, where the eye needs to have before it at one time a considerable extent of territory, in order to obtain a connected idea of its physical features, it is necessary that a compilation on a reduced scale should be made, by which a considerable number of sheets are compressed within the limits of one. Thus in the Ordnance Survey of Great Britain, maps on both the six-inch and the one-inch scale are furnished, and are equally in demand.

Having determined the degree of accuracy with which the work shall be prosecuted and the scale or scales which shall be used, it is necessary to decide how the vertical element, already alluded to, shall be exhibited. And this is a matter of some difficulty, and one in regard to which there have been formerly considerable differences of opinion. We have seen

how an idea of the relief of the surface can be given by means of light and shade, in the case of the photographic copy of a model, which is wonderfully effective in conveying the idea of differences of elevation, the effect depending exclusively on the distribution of the light and shade caused by the obliquely falling rays of the sun; were a photograph to be taken from such a model, with the rays descending vertically on it, the illusion or perception of the relief of the surface would be entirely lost. The same thing can be done, although less perfectly, by a skilful handling of the brush on paper, or by the lithographer on the stone with the crayon, giving a sort of bird's-eye view of the region to be mapped; and, in the hands of a thoroughly artistic worker, with an eye for topography, much may be accomplished in this way. This method of indicating the relief of the surface is used now to some extent, especially in maps of regions covered by mountain ranges, where a considerable area is to be shown at once, and where, from the nature of the country, as well as from the necessarily small scale adopted, it is not expected that anything more than a general idea of the topography can be given. The map of the Thian-Schan range, recently published by Petermann, and that of California and Nevada, by the Geological Survey of the first-named State, are good instances of the application of this method.

But for an accurate topographical survey, where it is desired and expected that a close approximation to the vertical element shall be obtainable from the map, and not merely a picture conveying a general idea to the mind, other methods have to be adopted. An approach to accuracy is made by shading the hills by means of short, straight lines, or *hachures*, as they are generally called. Most of our ordinary geographical maps have the position and direction of the mountain ranges delineated on them by these hachures, which, as ordinarily used, are only a sort of conventional symbol, intended to indicate vaguely the existence of a hill or ridge, or series of ridges, and too frequently having a perverse resemblance to a cluster of caterpillars crawling over the surface of the map. The original idea of these lines is, that they indicate the course which a stream of water would take in running down the side of the range, in

the line of most direct descent, thus furnishing a clew to the direction of the slope. Many years ago a German topographer, named Lehmann, gave a more precise value to these hachure lines, by proportioning their thickness to the angle of slope of the surface they were intended to represent. Thus, by this system the steeper portions of the slopes appear on the map in darker shade than the less inclined surfaces, so that the relief is indicated something in the same way as if the hill-shading were done by the brush, in the manner indicated above, while the eye can determine from the thickness of the lines employed, although only approximately, the angle of the slopes. Many beautiful maps have been made, according to this system or some modification of it. Thus the Dufour map of Switzerland, as it is called, in which Lehmann's method, modified by the introduction of an oblique illumination, was used, is a masterpiece of the chartographic art.

Topographical maps were formerly made, in Europe, almost exclusively for the purposes of military defence, that is, to guide generals in arranging the movements of their armies; and it is only in later years that the civil uses of these surveys have become more prominent. Hence, as the demands of commerce, agriculture, and manufactures have begun to be heard more frequently and louder than those of war, more accurate work has been required, and the insufficiencies of the hachure method for details have become evident. The angle of a slope was the important element when the movement of artillery up or down it was the question to be decided; but the civil engineer, who has the more peaceful object in view of building a railroad or cutting a ditch, wants a section of the line he has to pass over, or, indeed, sections of many lines, that he may choose the one best adapted to his purpose; and he wishes to know the absolute height of each point in that section above the sea-level, or some other datum line, which may have been selected as the plane to which all the heights should be referred. This is done by means of contour lines drawn upon the map, so as to connect points having the same elevation above the datum line, and at greater or less vertical distance from each other, according to the amount of accuracy and detail which may be required. The steeper the slope the

nearer to each other the contours will fall, so that an increased steepness of the ranges will be indicated to the eye at once by the crowding together of the lines, thus reproducing, in a measure, the effect of the brush-shading spoken of above. This method may be understood more easily by those unaccustomed to maps made in this way by using a simple illustration. If we suppose in a lake a mountainous island, a thousand feet high at its highest point, to be sunk by ten successive stages of one hundred feet each, then at each stage of the sinking the water will meet the land and mark a line upon it connecting all the points which are respectively 100, 200, 300, and so on, feet above the original level of the lake. The lines thus marked by the rising edge of the water would be exactly in the places which contour lines accurately run at vertical distances of 100 feet would occupy. Any person looking at such contour lines would see at a glance what portions of the island were 100, 200, and so on, feet above the lake level; and if the slopes were pretty regular, he would be able to get a good idea of the relative heights of all the other points intermediate between those lines. The advantage of this system of contouring, as it is called, is, that from any map on which such contour lines are indicated a section can be drawn at once, which will more or less accurately reproduce the slopes and exhibit the elevation of all points on that section. And such sections are invaluable and, in fact, indispensable, in operations connected with the building of roads, railroads, ditches, canals, and engineering work of all kinds. The degree of accuracy with which such sections can be drawn depends on the distance apart of the contours. In cases of great importance, and over limited areas, they may be fixed at a distance of two or three feet apart vertically. In ordinary topographical surveys they may be drawn at distances of from twenty to a hundred feet or more, according to the nature of the country and the contemplated accuracy of the work.

A good topographical map of any region, therefore, will have indicated upon it all natural objects, such as lakes, rivers, and smaller water-courses; artificial ones, namely, boundaries of fields, enclosures, roads, houses, etc.; and, besides these, it will exhibit to the eye and furnish for use the vertical eleva-

tion at all points above the level of the sea, this being usually chosen as the datum line from which the altitudes are reckoned. And by "level of the sea" is usually meant mean low tide, or else the mean between mean low and mean high tide.

Thus far we have chiefly confined our remarks to the methods by which topographical information is brought into an available form, so as to be presented to the public on paper. And, indeed, many persons are so little acquainted with this kind of work, that they imagine the plotting of the survey and putting it into the form of a map to be the essential thing. This is the case indeed with most or all school-maps and with many others which are offered to the public, especially in this country; they are simply compilations and workings over of other people's labors. But wherever an accurate map exists, there must have been done by somebody, and at somebody's expense, in the field, an amount of labor, and that of a kind demanding the highest degree of skill and immense patience, compared with which the mere plotting and engraving of the work is comparatively insignificant. Few persons, except those themselves professionally engaged in such surveys, have any idea of the amount of labor, and of course of time and money, required by a thoroughly accurate topographical survey, even if the area over which it extends be one of moderate dimensions. It may seem an easy matter to measure a line on the ground of half a dozen miles in length; and so it is, if the region be level and it be a matter of no consequence whether the measurement be correct, provided it comes within a few inches of the truth. If a traveller wished to know the distance from one town to another, he would consider it quite a superfluous degree of accuracy that he should be informed to the nearest rod; while in buying a piece of land in a large city a difference of half an inch in the width would be a matter of importance. Now, while most of the determinations of position from which the skeleton of a map is made are done by means of the measurements of angles and not of lines, there must be, to start with, a base measured somewhere on the surface, as a necessary preliminary to the triangulation, or the angular measurement of the net-work of triangles which covers the region to be

mapped, and which forms the frame, so to speak, into which all the details are to be fitted. This base line must, however, be measured with the utmost precision, even down to the smallest fraction of an inch; for any error made at this preliminary stage of the work would be many times magnified as the work was extended from its original starting-point, and the value of the whole would be destroyed. It would be hardly possible to convey to the uninitiated an idea of the skill which has been bestowed on the construction of the instruments with which this base measuring is to be done, and of the patience and care with which they must be used. With the apparatus devised by Bache and Würdemann, and used on the United States Coast Survey work, distances are measured with such precision that the probable error in one mile is only about two hundredths of an inch. And to show the accuracy with which the work may be extended from a measured base by triangulation, it may be stated that a line 5.4 miles long on Chesapeake Bay was connected in the primary triangulation of the United States Coast Survey with a measured base of 8.7 miles on Long Island, the two being 208 miles distant from each other in a straight line. Yet the measured length of the base of verification on Chesapeake Bay agreed with its calculated length, as determined by computation of thirty-two connecting triangles, within four inches. Thus the same degree of accuracy is required in the angular as in the linear measurements, the instruments required for each of them being alike delicate and ingenious in their construction and requiring the most refined skill for their handling. As a general rule, the sides of the primary triangles should be made as long as possible; that is, the two ends must be as far apart as vision aided by powerful telescopes can be extended. The object sighted at one end of the line is a beam of the sun thrown by a mirror directly into the axis of the telescope at the other end. By this beautiful contrivance the stations may be in some cases as much as a hundred miles distant from each other, while the average length of the sides of the primary triangles in the Ordnance Survey of Ireland is fully sixty miles. This preliminary work is called the main or primary triangulation, and the points fixed in position by it are determined with all the precision

that is possible by means of the most refined observations made with the largest and most perfect instruments that can be constructed. Further approaches to absolute accuracy are made by means of frequent repetitions of the observations, which are afterwards examined by the aid of mathematical analysis, so that every possible source of hidden error may be detected. It is to the points thus determined by means of the primary triangulation that the rest of the work is connected and referred; a less degree of accuracy being required for the secondary and tertiary triangulations, because these can always be checked by means of the primary stations. This more detailed work is simply a dividing up of the large triangles into smaller ones, each step in the operation having as its object the fixing of the position of more points; and this is carried on until the whole surface of the country has been cut up into triangles of suitable dimensions. In the British Ordnance Survey over districts where the scale of six inches to a mile is to be used, two points have been fixed by the triangulation on every square mile; and where the scale is five feet to a mile, sixteen points have been determined on the same area. Into the framework thus elaborately prepared the minute details are fitted, and this is done of course by the aid of comparatively small instruments, the use of which requires much less skill than is needed when the larger ones have to be employed. The plane-table is almost exclusively used on the Continent of Europe for the detailed work; and by means of this instrument the work is plotted on the field, and only needs to be inked in afterwards. By the aid of photolithography these plane-table sheets can easily be multiplied to any extent; and it is one of the greatest advances recently made in topographical surveys, that the original work can thus be cheaply duplicated, and that all land-owners can have without delay copies, on the largest desired scale, of the original surveys of their own property.

Having thus explained as concisely as possible the nature of the operation of a topographical survey, it will be desirable to refer briefly to what is being done in Europe in the way of preparing accurate maps of the different states, before passing on to a review of our own needs. But space will not admit of

our doing anything more than merely to indicate, for a few of the most prominent countries, the scope of their topographical work; the simple catalogue of the great maps in process of publication in Europe, made as concise as possible, would occupy many pages of this Review.

Let us begin with Great Britain, which, including Ireland, has an area of nearly 111,000 square miles, and where the topographical survey has been going on since about 1784. The scientific work is partly performed by officers and privates of the Royal Engineer Corps,* and it is officially known as the "Ordnance Survey." Its total cost, from 1791 to the end of 1864, including the military pay of the men employed, was £2,991,624, and may be estimated to have been up to the present time about £4,200,000. The scales adopted are numerous, and in case of some cities are as large as five and even ten feet to the mile. The principal published maps, however, are on two scales, one of six inches, and the other of one inch to the mile (1:10,560 and 1:63,360). Of England the map on the one-inch scale was begun in 1784 and finished in 1869; but the projection employed in it was defective, and it is in other respects not up to the present requirements of the country, hence it is now in process of working over and republication. Of the area surveyed on the six-inch scale, 24,877 square miles had been completed in England and Wales, and 27,829 in Scotland, up to the end of 1873. Ireland, on the same scale, was entirely finished in 1845, and all the sheets, 205 in number, published without, and about half with, the hill-shading. Besides the maps on the six-inch and one-inch scale, plans are furnished of any district as called for, on the scale of 1:2,500 (about 25 inches to the mile), made by photozincography; but these are not necessarily engraved or published. The map of London is on a scale of 1:1,000, and is comprised in 821 sheets. The various publications of the Ordnance Survey are sold in single sheets as wanted, at very moderate prices; but so great is their number, that the cost of a complete set, as far as already published, amounts to over £3,000. A great deal of work is prepared for the use of

* 382 military, including officers, and 1,446 civil assistants were on the Ordnance Survey staff in the year 1872.

the government on very large scales; but it is chiefly the six-inch and one-inch maps which are of importance to the general public. At the present rate of progress it will require about ten years to complete the survey.

In Belgium the scale adopted is 1: 20,000, the area of the country being about 10,000 square miles; 450 sheets will be required, of which 137 were published up to the end of 1873; the contour lines are drawn at distances of one metre, every fifth one being indicated by a heavier line; the sheets are lithographed and printed in colors, the rivers and lakes being in blue, the lettering and roads in black, the meadows and forests in different shades of green, the buildings in brick-red, and the gardens in carmine.

In Prussia, since 1849, new and more perfect methods have been introduced into the topographical surveys; the plane-table sheets are now published on a scale of 1: 25,000, and with contour lines at distances of 5, 12½, or 25 feet, according to the nature of the country. The publication of the plane-table sheets was commenced in 1868, and in 1873 120 had been issued. There has also been, since 1841, a general map in process of publication, on a scale of 1: 100,000, which will be comprised in some 400 sheets, of which nearly all are issued. These are engraved on copper and have the topography, or hill-shading, indicated according to Lehmann's system, as modified by General Müffling.

In Baden, the new map was commenced in 1874, on a scale of 1: 25,000, and with contour lines at 10 metres' distance. The work is mainly a revision and correction of older surveys, and is expected to occupy six years, at a cost of about 80,000 florins.

In Saxony, the original survey was commenced in 1780 and completed in 1806 on a scale of 1: 12,000, the area of the kingdom being 5,600 square miles. A topographical map was issued in the years 1837–1860, in 22 sheets and on a scale of 1: 57,600. A new map was determined on in 1860, on a scale of 1: 100,000, and it was completed in ten years; there are two editions of this, one with the line-work only and the other with the hill-shading.

Having now shown what is doing in some of those European states which are, comparatively speaking, rich, densely inhab-

ited, and with moderate areas of territory, let us turn to the consideration of some countries which have only a thinly scattered population and a large area. Russia, for instance, with its enormous territory, just about twice the size of that of the United States, Alaska included, has been for many years actively engaged in prosecuting geographical surveys. The map of Russia in Europe, embracing about 2,100,000 square miles, has been under way since 1857, and will be embraced in about 700 sheets, of which 454 had been published in 1872. This is on a scale of 1:126,000. The military map of Poland is on the same scale, and is embraced in 57 sheets, all of which are published. Special maps of the Caucasus have also been completed; and, recently, a map of Central Asia. Norway has an area of 123,300 square miles, and a population about that of Massachusetts; that is, our own State is eighteen times more densely populated than Norway. But this comparatively poor country has set itself on having a good topographical map on a scale of 1:100,000, and which will occupy over 200 sheets. Those which have already appeared have been highly praised for their execution by competent judges; they are printed in chromolithography, like those of Belgium. Sweden also, very similar to Norway in respect to area and density of population, has her topographical maps on the same scale (1:100,000), and the work is already nearly half completed, the first sheet having been published in 1860.

We have thus given, necessarily in a very concise manner, some idea of the scope and methods of topographical surveys; and, before going on to consider what has been done in this country, it will be well to say a few words on the methods employed for mapping regions where, owing to the nature of circumstances, only imperfect work can be done, as in the first rough reconnoissance of an uncivilized region, or where the poverty and ignorance of the people have not yet allowed them to grasp the idea of a geographical map, and where consequently all such work has to be done for them by other nations. In parts of Central Asia the topographer must get what information he can, without the use of instruments, and not even exhibiting a note-book, but trusting almost exclusively to memory, or to a few hasty lines pencilled at moments when the

jealous vigilance of the natives might accidentally be relaxed. Most of our knowledge of the geography of Central Africa, such as it is, has been got almost without instrumental assistance. In such cases distances have to be guessed at, or roughly determined by keeping an account of the time employed on the march and estimating the pace of the animals ridden or driven. An odometer fastened to a wheel of the vehicle gives a still better approximation, when the ground is not too rough. Schweinfurth, the eminently successful African traveller, having lost his watch, with untiring patience counted his steps for six consecutive months, thus getting a quite respectable basis for a plotting of the region traversed. The direction is kept by means of the magnetic compass, and a great deal of valuable information has been obtained by these most simple means for determining the relative position of the various objects noted. The geographical traveller, however, usually has at his command the means of more or less accurately checking his daily sketches of the country, by means of astronomical observations. One element of geographical position, the latitude, is easily determined with portable instruments, for the use of which but little skill is required; but the fixing of the longitude, even if only to within a few miles of the truth, is a matter of considerable difficulty. To determine the longitude, so that the result may be depended on as being not more than two miles in error, requires a long series of observations made with skill, and with instruments which can hardly be called portable. But within the last few years the construction of numerous lines of the magnetic telegraph, some of which run through quite uninhabited regions, as, for instance, the one traversing Australia from north to south, has made the accurate determination of longitude comparatively easy in many places where before it was almost impossible, and has thus rendered great services to geography. The chronometer, which does such excellent service at sea, is of very little use to the traveller by land, except for rough work, since the inevitable jolting consequent on moving about in wagons or on horseback is fatal to the accuracy of its going.

With these preliminary remarks, which, it is hoped, will make that which follows intelligible to the general reader, we pass to the consideration of the progress in geographical work

in our own country. And, first, we have to call to mind the extent of our territory and its very diversified character; and, with but slight consideration, it will be evident that different portions of our vast area are very differently situated as regards their chartographic necessities. Without taking Alaska into consideration, we have, roughly speaking, three millions of square miles of territory, embracing almost every conceivable variety of soil and climate, and including the grandest expanse of fertile plain and the roughest and most inaccessible ranges of granite pinnacles. Valleys meandering among low forest-clad ridges, and offering every inducement for settlement and cultivation, are present in one part of our country; while, in another, we have precipitous cañons, cut through the solid rock to the depth of thousands of feet, and from the edges of which one may have in full sight an abundance of wholesome water, and yet die of thirst, from the sheer impossibility of climbing down the almost vertical walls by which the stream of life-giving fluid is hemmed in. The Atlantic Slope, the Appalachian Ranges, the Mississippi Valley, the Plains, the Great Basin, the Pacific Slope, — these all have their peculiarities of soil and climate, and are suited to invite settlement in very different degrees; so that, while portions of our territory are already densely populated, others are uninhabited, unless by a few half-starved, wandering Indians, and will always remain so. It is evident, therefore, that no one system of topographical work would be applicable equally to all parts of the country; but that a judicious discrimination will have to be exercised in selecting scale and methods best adapted to the varying wants of each particular section. It must also be remembered that, in the conflict between State and United States authority, different parts of the country are very differently situated as regards their rights and duties in this very matter of topographical surveys, as will be explained more fully when speaking of the United States Land Surveys. No one can doubt that Congress, if it saw fit, could organize and cause to be conducted to completion a topographical, or a combined topographical and geological, survey of the whole area of our country; but this has not been done, nor is there reason to suppose that it will be. Something has been accomplished,

however, and that must now be examined. And we will speak first of the preliminary reconnoissances and surveys which have been undertaken, mostly by the authority of Congress, and in the region west of the Mississippi, because nothing of this sort has been done, or needed to be, in the Atlantic States, or in the region east of that river, where the "Land Office Surveys," to be noticed further on, have long been established.

Twenty-five or thirty years ago the western half of the North American continent, north of Mexico, with the exception of its coast line, roughly laid down by the old Spanish and English navigators, was known to geographers only in the vaguest possible way. The courses of the principal streams — the Missouri, the Columbia, and the Colorado — had been approximately mapped, it is true; but the details of the interior were not much better known than is the centre of Africa at the present day. Up to the time of the acquirement of California from the Mexicans by the United States, progress in the exploration of this vast region had been extremely slow. Our government had little idea how soon the Pacific side of the continent was to become an important part of our Republic. From time to time, since the beginning of the present century, small expeditions had been sent out to explore its trackless wastes; the daring and restless fur-traders had wandered vaguely over regions which it seems incredible that they should have had the audacity to reach; and, from their rough notes and unskilled observations, maps had been put together in which the outlines of the physical structure of the country began dimly to appear. As late as 1826, however, our maps represented a narrow chain of mountains as traversing our whole territory from north to south, in longitude 105° to 110°, and dividing the waters flowing into the Atlantic from those tributary to the Pacific. Besides the Columbia and the Colorado, three other great rivers were indicated as heading in the Rocky Mountains, and running directly west to the Pacific. These were called the Buenaventura, the Timpanogos, and the Los Mongos. Thus the existence of the most striking feature of our western geography — the Great Basin — was entirely unsuspected at that time.

The memorable expedition of Captains Lewis and Clarke,

in 1804 to 1806, — the first important one ordered by our government, — had made known the position of the Upper Missouri and the Columbia; and the excursions of the Spanish-Mexicans, from the southwest, had furnished us with the materials for indicating the course of the Colorado with some approach to accuracy; but all the region between this river and the Columbia, comprising an area of about half a million of square miles, was vague and indefinite. Even Lewis and Clarke, who were generally extremely careful and accurate in their work, considering the means at their command and the circumstances of the party, were deceived by the size of the Willamette at its mouth, and represented it on their map as heading far to the east in Salt Lake; while, in reality, its course is really parallel with the Pacific coast, and at but little distance from it.

Major Pike was the first American explorer who reached the sources of the Colorado, and the second who crossed the divide between the Atlantic and the Pacific Oceans. This was in the years 1805–1807, just after the return of Lewis and Clarke. In this expedition — made to explore the sources of the Arkansas — Pike struck a large stream, which he supposed at first to be the Red River, and afterwards the Yellowstone (so vague was the knowledge of our geography at that time), but which is now known to have been the source of Grand River, the southernmost of the two great branches which unite to form the Colorado.

Humboldt's map, accompanying his great work on New Spain, was compiled and published soon after the explorations of Lewis and Clarke and Pike had been completed, and contained all that had been ascertained by the Spanish-Mexican explorers about the territory now included within our domain as far north as latitude 42°. This map was less in error, in some important particulars, than many others published years later, for it did not show any rivers heading in the Rocky Mountains and running due west to the Pacific. Great Salt Lake had been indistinctly recognized at that time; and a body of water with that name, the limits of which were not defined, is given on Humboldt's map; while the existence of another large one farther north, and called Timpanogos, is

indicated as doubtful: this latter one was laid down on much later maps, as being the head of the Los Mongos River. The name Los Mongos has disappeared from our maps, but that of Timpanogos * still exists, and is given to a small stream running into Utah Lake.

Major Pike was the discoverer of a prominent mountain, called by his name, at the base of which he camped, and for which he seems to have entertained an almost superstitious reverence. He says that "it is so remarkable a mountain as to be known to all the savage nations for hundreds of miles around"; and he did not attempt to climb it, for "no human being could have ascended to its pinnacle." Its elevation he estimated at 18,851 feet. This mountain for some time gave the name to what is now the State of Colorado; and when the discovery of gold began to draw a crowd of emigrants in that direction, they were universally known throughout the West as "Pike's-Peakers." The elevation of this point is now known to be a little over 14,000 feet, and a United States Signal-Service station has been established on its summit.

The expedition of Major Long, in 1819, 1820, to the head of the Platte, was the first one sent out by our government, equipped in anything like a respectable manner, and provided with scientific observers and naturalists, charged with the investigation of the geology and botany of the region traversed. One of the high peaks of the Rocky Mountains, and the only one visible from the line of the Pacific Railroad, bears the honored name of Long. The same officer afterwards made the first exploration of the Minnesota or St. Peter's River. The sources of the Mississippi were roughly mapped by Lieutenant Allen in 1832.

Up to this time we were still without any definite knowledge of the region between the Colorado and the Columbia. The existence there of a large salt lake was vaguely known, and had been for a hundred and fifty years, much that was mythical being connected with it by various geographers. There is little doubt that it had been seen and navigated by American fur-hunters as early as 1824; but they never thought or cared to publish to the world the facts they had observed. Captain

* "Timpan" is the Shoshone word for *rock*.

Bonneville, of the United States Army, was the first educated man to visit this remarkable interior lake, and to ascertain and make known that there was a vast region, between the Rocky Mountains and the Pacific coast, of which the waters had no drainage to the sea.

Bonneville's expedition was not under the patronage of the government; he obtained, however, leave of absence from the army as well as leave to pay his own expenses, and to furnish himself with instruments; and, because he stayed away somewhat longer than was expected, he was dismissed the service. Indeed, Bonneville seems to have been a man very ill-used by fate; for his work was forgotten or ignored by subsequent explorers, notably by Fremont; the names he gave to the prominent features of the country which he discovered were never adopted, and not even the influence of Washington Irving was sufficient to make the intrepid explorer's name stick to the lake he was really the first to make known to the world. He never even got so far as to be a candidate for the Presidency; neither was he called the "Path-Finder"; that name he must have dropped somewhere on his route, for the one who followed him picked it up.

Bonneville went entirely around the Great Basin, going out by the Valley of the Humboldt, which he called Mary's River, and returning by the old Santa Fe trail, which was the one used by the native Californians in travelling from the southern Spanish settlements on the Pacific coast to Santa Fe. His narrative, edited by Irving, was published in Philadelphia in 1837, in two volumes, with two maps. It does not appear, from anything that Fremont published, that this work had ever come under his notice.

Nicollet, a Savoyard, who came to this country about 1831, and who was a skilful practical astronomer, did a good amount of valuable geographical work in the years 1836–1843, first on his own private responsibility, and afterwards in the employ of the government, and chiefly about the sources of the Mississippi. The region he explored, and was the first to map approximately, has since been surveyed by the United States Land Office and has become the flourishing State of Minnesota; but the value of Nicollet's service, as one of the pioneer geog-

raphers of the country, cannot be forgotten. He was the first explorer in this country who used the barometer with skill for the determination of elevations in the interior, and it was as his assistant that Fremont learned the use of portable astronomical instruments.

We have now mentioned all the most important reconnoissances and explorations, having for their object the development of the geography of the Far West, previous to those of Fremont. With this energetic and intrepid, if not always judicious, explorer, may be said to have commenced the first systematic investigation of the geography of the region west of the Rocky Mountains. Thanks chiefly to the influence of his father-in-law, Colonel Benton, Fremont, whose explorations began in 1842, was well fitted out by the government both as to men and instruments, and he had a great advantage over all previous workers in that field, in that he was accompanied by a skilful assistant, Charles Preuss, so that he could devote himself to the astronomical observations, while Preuss attended to the delineation of the topographical features of the country, — a kind of work in which he was highly proficient. Fremont made several expeditions across the mountains, in the fourth and last one of which the party suffered terribly, having been overtaken by winter snow-storms, so that, as is universally believed in California, they were driven to actual cannibalism.

It is only the three first expeditions which are important, or of which any account has been published. The first was in 1842, up the Platte to the Sweetwater, then to the Wind River range, and back down the North Platte. The reports of this and the next expedition — that of 1843 and 1844 — were issued together, and have been much more widely circulated and read than any other geographical documents of the kind ever published in this country. This second expedition, in which Fremont supposed that he had discovered the "Great Basin," in which, as we have seen, he was anticipated by Bonneville, was really a grand triumph over every kind of obstacle; it was, however, less remarkable than that of his predecessor; since, while the one was accompanied by a large and well-armed party, provided even with artillery, the other was only one of a small band of volunteer explorers, more than half of whom were

swept off in one battle with the Indians. Fremont's party started from Kansas in May, 1843, on the second expedition across the mountains. They followed up one of the branches of the Platte, through the Black Hills, up the Sweetwater, to South Pass, — then generally supposed to be the proper line for a railroad across the continent, — thence by a circuitous route to the Boise River and the Columbia; thence on the east side of the Cascade Range, by Pyramid and Mud Lakes, down the eastern edge of the Sierra Nevada, which was crossed in midwinter after much suffering and many dangers. At the great ranch of Sutter, one of the survivors of the Swiss guard of Charles X., who had settled near the junction of the American River with the Sacramento, Fremont was hospitably received; and, after recruiting his party, he started on the return trip, going south to the head of the Tulare Valley, and then recrossing the Sierra, and back through the southern portion of the Great Basin to the Parks of the Rocky Mountains, and down the Arkansas to the starting-point, which he reached after fourteen months of almost continuous journeying.

Of the next expedition, in 1845–46, the results have never been published; but in 1848 a map was issued, accompanied by a pamphlet entitled "A Geographical Memoir upon Upper California." This map was the first representation of our Western territory which made anything more than a distant approach to correctness. It gave at least a tolerable general idea of the most striking geographical features of the region: the Parks, the Sierra Nevada, the Great Basin, with its nearly parallel north and south ranges; the great Lava Plain of Oregon; the dry plateaux of Southern Utah and California: these were all indicated with more or less clearness.

And now, just at the close of Fremont's career as an explorer, came an event which had a lasting influence in a variety of directions, and among others in that of the geography of the West. The Californian gold excitement, and the consequent rush of emigration across the plains to the Pacific shore, seemed all at once to bring that region close to us which had been before so distant and little cared for. The establishment of a line of steamers by way of the Isthmus of Panama to California led to the building of a railroad to con-

nect the two oceans at a convenient point. Soon communication by rail through the heart of the continent began to be talked about, but at first as something only possible perhaps in a distant future. The matter was more and more discussed, and then Congress was appealed to, and it was urged that a survey should be ordered for the purpose of ascertaining the most feasible route. Appropriations were made for this purpose, and several surveying parties organized under the direction of the Secretary of War, officers of the United States Engineer Corps being placed in command of them. The work was continued from 1852 to 1857; and in addition to the reconnoissances made with a special view to railroad routes, there was considerable topographical material collected, and quite a number of naturalists were also employed in investigating the geology of the region traversed, and in making collections in all departments of natural history. The routes explored were near the forty-ninth, forty-seventh, forty-first, thirty-eighth, thirty-fifth, and thirty-second parallels. The work was hastily, and some of it carelessly, done, most of the persons employed having had little or no experience in topographical or geological surveys; but, on the whole, the results formed a large addition to our previous stock of knowledge; and the collections, especially, were of great value as giving the material for making out a pretty full account of the distribution of animals and plants over the vast area traversed by the exploring parties. Thirteen ponderous quartos were issued within two or three years after the field work had been completed, and are familiar to all — as to their exterior, at least — as the "Report of the United States Pacific Railroad Surveys." Maps were made by each party of the region embraced within the area of its explorations; and from them, and all other available sources of information, a general map was compiled under the direction of Lieutenant (now General) Warren. This map has been so much altered and worked over at the United States Engineer Bureau, since its first appearance in 1857, that it has but little now remaining on it of the original material. Its scale is about forty-seven miles to an inch, and it was compiled and drawn with great care and skill by Mr. Freyhold, much difficulty having been found in reconciling the

erroneous and conflicting determinations of longitude, as is fully set forth in the elaborate and valuable memoir by General Warren which accompanied the map in question. Indeed, it was especially with regard to longitudes that the United States Pacific Railroad surveys were deficient, there being but few good instruments taken into the field, and fewer still of good observers who went with them. A delay of a few months in beginning the work, supposing the interval to have been devoted to preparing suitable instruments and training observers in their use, would have added greatly to the value of the results. As it happened, curiously enough, not one foot of the ground explored by these parties for a transcontinental railroad is passed over by the line as it has actually been built, excepting the valley of the Humboldt River, which was part of the regular emigration route at that time, and almost an unavoidable link between the Atlantic and Pacific.

The Mexican and Northwestern boundary surveys have accurately fixed the lines which separate us from British territory on the north and Mexican on the south. The former was completed in 1856, and the latter much more recently. The results were of little value from a geographical point of view, since the topography was worked up only in the immediate vicinity of the lines surveyed. A Report on the Mexican Boundary Survey was published by our government, in two volumes, and illustrated without regard to expense, the most valuable portion of it being that relating to the botany of the region adjacent to the line. No full report has ever been issued with regard to the running of the Northwestern boundary, nor have any of the maps been published. The line has been established and marked, and left to time and the Indians to take care of. So with other government surveys of lines dividing the individual States. They have not been creditable to the country, either in the methods or accuracy of the work; neither have they added much to our knowledge of the geography of the country, and rarely has anything been published in regard to their results. The work done on the line between California and Nevada is one of the worst instances of this putting of costly and important undertakings in the hands of incompetent men.

The expedition of Lieutenant Ives up the Colorado River, made in 1857, 1858, developed interesting facts in regard to the physical geography and geology of that very remarkable region; but the chartographic portion is very defective, the work having been of the most sketchy description.

At the time of the commencement of the War of the Rebellion, there were several reports of geographical explorations in the possession of our government, whose publication was delayed by the troublous condition of the times, and which appear now to be buried in the archives of the departments at Washington, and destined never to see the light. One of these reports was an important one; it related to an expedition under the direction of Colonel Macomb, having for its object the exploration of the San Juan River, one of the principal affluents of the Colorado on the south side. Another was that of General Warren's reconnoissance, in 1855–1857, in Nebraska and Dakota; and still another contained an account of the reconnoissance of the head-waters of the Missouri and the Yellowstone under Captain Raynolds, in 1859, 1860. The geographical results furnished by these various expeditions, and by many other less important ones, made under government auspices, have gone to the United States Engineer Bureau, and have been utilized in working over Warren's map of the United States. They were all reconnoissances, and almost without exception too defective in the astronomical determination of position to allow of their being used, except for a general map on a very small scale, where detail was not necessary, and where discrepancies of a few miles could be easily put out of sight.

Up to 1860, the United States had been entirely unsupported by the individual States and Territories in the work of adding to our stock of geographical knowledge of the Far West. The Land Office Surveys — of which more presently — had made some progress in California and Oregon; but hardly a beginning elsewhere to the west of the Rocky Mountains. These two were, indeed, the only organized States west of the 104th meridian, and they together hardly contained half a million of inhabitants; but little was therefore to be expected from this quarter, unless done by the central government. At this time

there was a good general knowledge of the geographical outlines of a large part of the region west of the Mississippi; only the southern and western portions of what is now the State of Nevada and a part of Utah were still marked on our maps "unknown." No detailed work, however, had been done in all this vast region, and the structure — both geographical and geological — of the mountain ranges was something which had not received the slightest attention. Even the elevations of the prominent mountains were unknown; not a single high peak, in all that vast complex of ranges which we call the Cordilleras, had ever been measured. There was also the chronic difficulty with regard to longitudes. Not a single point between the Mississippi and the Pacific coast had been accurately enough determined to justify its being used with confidence for subordinating other work to it. Salt Lake itself, which ought to have had the best established position in the region, since it had been made the special object of a costly expedition, was found by the telegraphic observations of the United States Coast Survey, in 1869, to be six miles east of the position which had been assigned to it by Warren.

In 1860, the State of California made a beginning in the direction of accurate work, by the establishment of a geological survey. Among the provisions of the Act, by which the work was authorized, was one requiring the preparation of "suitable maps," and this was construed by the State Geologist to mean maps as accurate as could be made with the means at his command. In the ten years during which this work was carried on, considerable progress was made in developing the detailed structure of both the Coast Ranges and the Sierra Nevada, and several maps were published, on scales of two and six miles; and also a general one of both California and Nevada, on the scale of eighteen miles to the inch. An important work in four sheets, giving the topography of the whole Sierra Nevada, on the scale of 1 : 380,160, was nearly completed, and three sheets had been engraved in a style worthy of high praise, when the work was suddenly stopped by the Legislature in 1874, although the entire expenses of the survey in all departments, including geological and natural-history work as well as the costs of publication,

had been considerably less than $20,000 per year from the beginning.

The explorations of the Central Pacific Railroad, for establishing their line, gave the first clear idea of the topography of the region between Salt Lake and the Sierra Nevada, along the thirty-ninth and fortieth parallels, — a region traversed by more than twenty nearly parallel ranges of mountains, many of which are little inferior in height and elevation to the Pyrenees. Several lines were surveyed through Nevada, in the hope that a feasible route might be found across these ranges, and that thus the road might be run direct to Salt Lake City, without the long detour to the north, by way of the valley of the Humboldt, by following which they would be obliged to leave what were then the most important mining districts of the Great Basin far to the south. By combining these surveys, which were executed by Butler Ives, a skilful topographer, a quite accurate map of the northern portion of the Great Basin was obtained; which, however, was never published. This map covered almost precisely the same ground as the western half of the Fortieth-Parallel Survey, of which more presently. The Union Pacific Railroad made no surveys having any topographical value; but those of the South Pacific added some few items of importance to what was previously known of the region at the base of the Rocky Mountains in Colorado and New Mexico. The Northern Pacific, on the other hand, contented itself with compiling, from Warren's map and other authorities, a large and geographically worthless diagram, which was widely circulated, with the proposed route of the road indicated on it, and the sterile deserts of the Northwest as far north as latitude 52° marked in large capitals, "The Continental Wheat Garden!"

The "United States Fortieth-Parallel Survey" and the "United States Geographical and Geological Survey of the Territories" will be noticed further on, when we come to speak of work now in progress. At present, we have to turn our attention to what has been done in the States east of the Mississippi, and in the inhabited portions of the great valley of that river, towards working up the geography of the eastern half of our territory. And it may, in the first place, be

stated, that for the valley of the Mississippi we have to depend chiefly on the United States Land Surveys, while for the Atlantic States the basis of our geographical knowledge is the United States Coast Survey, supplemented by a large amount of material of a very mixed nature, and not at all thorough in execution or trustworthy in detail. To appreciate the chartographic condition of this portion of the country, it will be necessary, first, to give some idea of the operations of our Coast Survey.

The United States Coast Survey is a work of such magnitude, so important to the geography of the country, and, withal, so creditable to American science, that it will be proper to take some pains to make ourselves acquainted, in a general way, with its methods and progress. It is the only great scientific work in this country which has been uninterruptedly carried on for any considerable time; and one of the few things done under the authority of the national government in which every American citizen can take pride. The importance of an accurate knowledge of the coast line of a commercial country like our own was something that the dullest and least scientific mind could hardly fail to perceive, and it is not surprising that such a survey was ordered; but it is, indeed, something to be wondered at, that a work, requiring such an amount of time and so large an expenditure of money, in order that it might be executed in a creditable manner, should have got itself fairly established as a national institution. Having been started, it was rather to be expected that it would be put in charge of some one who would contract to have it done within the shortest possible limit of time, and who would have had but one idea, — that of pocketing the largest amount of profit at the end of the operation. Indeed, it is rather a matter of luck than anything else that the Coast Survey became what it is, and, being what it is, has continued to exist. Such a work needed, as its head, a man, not only of extensive scientific acquirements, but at the same time of extraordinary executive capacity. Such a man might, perhaps, be found without great difficulty; but he must, in addition to the necessary scientific and executive ability, possess the art of managing politicians, and the personal, mag-

netic influence needed to carry, every year, a bill through Congress, sanctioning the expenditure of a large sum of money. Bache had all this, and, besides, a tenacity of purpose which no amount of opposition could overcome.

The Coast Survey, as first started, was placed, in 1807, under the direction of Hassler, a Swiss by birth, who had emigrated to this country in 1801. He was a man of high ability, and his ideas of scientific accuracy were far beyond the comprehension of the men of his day in his adopted country. He was, however, a very eccentric individual, quite wanting in tact and executive ability. He had the fixed idea that he was the only person in the country who knew anything about geodetic work; and he was probably very nearly right, at the time the work commenced, although great progress, in that respect, had been made before his death, which took place in 1843. But for sixteen years of the time since the survey was commenced, the work had been suspended, owing to the financial troubles following our second war with England.

In 1844, Bache was appointed superintendent of the Coast Survey, and he continued actively engaged in the duties of that position until 1864, when, overwhelmed by the load of care and responsibility which this survey, and many other scientific labors incident to the War of the Rebellion, laid upon him, his health gave way, and he was obliged to leave the country, in the hope that repose and freedom from care would restore the powers of the disorganized brain. But the relief came too late; he lingered on, retaining the nominal superintendency until 1867, when his troubled spirit found eternal rest.

At the time of Hassler's death, the Coast Survey was in progress between Rhode Island and Chesapeake Bay, a single base from which to start the work having been measured on the south shore of Long Island. Five large charts had been engraved, but nothing published. Bache at once recommended the adoption of a more comprehensive system, and succeeded in obtaining the approval of Congress and the necessary funds. According to this system, the coast was divided into several distinct sections, as nearly of the same extent as convenient, and work was commenced and carried on simultaneously in each of them independently of the others. There are eleven

such sections in all, each, as a rule, with its own base line. Of the accuracy with which these bases have been measured, we have already spoken in the preceding pages. By the aid of the triangulation carried along the coast, in accordance with the principles already indicated, the shore line has been laid down with accuracy, and the minute details of the topography given for a distance of from one to three miles inland, according to the nature of the locality. This fixing of the exact position of the line of the coast forms the basis of the hydrographical work, which is the part of the survey of the most importance to the mariner and to commerce, but with which we have not to occupy ourselves in this connection. It is with the work of the Coast Survey, as forming the basis of the chartography of the interior of the Atlantic States, that we have to do at present.

As the net-work of primary triangles extends, owing to the great length of their sides, far back from the coast, a considerable number of interior points are thus fixed accurately in position, and the work of the Coast Survey thus affords a basis for a convenient extension. Favored by the remarkably indented character of parts of our shore line, some States, like New Jersey and Maryland, have really had no inconsiderable portion of their topography thus accurately given them at the expense of the United States.

A few years ago a beginning was made towards extending the triangulation of the Coast Survey farther into the interior than was needed for strictly coast work, with the idea of thus preparing the way for making the survey a national one, and doing away with its limitation to the shore line. The first reference to anything of this kind we find in the Report for 1870, in which the superintendent states that a new item is introduced into the estimates, "small in amount, but of inestimable importance to the scientific accomplishment of the survey." The item in question is, "for extending the triangulation of the Coast Survey, so as to form a geodetic connection between the Atlantic and Pacific coasts of the United States." The amount asked, which was granted by Congress, was only the almost insignificant one, as compared with the total demanded for the work, of $15,000; the whole amount

called for to continue the survey being $746,000, while $643,000 was the sum actually voted by Congress for the previous fiscal year. In the Report of the succeeding year, 1871, we find that this estimate was increased to double the sum previously asked for, namely, to $30,000, and the proviso added, "that the triangulation shall determine points in each State in the Union which shall make requisite provision for its own geological surveys." In the same Report, information is given in regard to work done during the year in this department of the survey, and it is stated that a "few geographical positions had been determined in the vicinity of St. Louis, and others in the States of Ohio, Illinois, and Kentucky." Further on in the same Report, mention is made of the determination of geodetic points in New Hampshire, the triangulation being extended from the coast across the State, in the direction of Lake Champlain. A similar beginning was also made in the vicinity of St. Louis. For the year 1872–73, the amount appropriated by Congress for this interior geodetic work was $36,000, and the same for the next year; for 1874–75, and 1875–76, the appropriation has been increased to $50,000. What has been accomplished up to the present time, as we learn from the Superintendent of the Coast Survey, is as follows: *reconnoissances preliminary to triangulation*, from the Blue Ridge in Virginia to the Ohio River; through Southern Pennsylvania, and in the same latitude in Missouri; near Salt Lake, for a base-line site and for points to extend triangulation east and west of that site: *triangulation commenced*, east and west of St. Louis; from San Francisco, to cross the Sierra Nevada to the meridian of Austin, Nevada, and from Monte Diablo up the Sacramento Valley to Mount Shasta. Geodetic work or preliminary reconnoissances have been or are in progress in sixteen States.

The highest geodetic problem of the Coast Survey, that of working up the observations with a view to contributing to our knowledge of the form and size of the earth, or, as it may be technically expressed, in the words of the superintendent, "finding the geometrical expression for a surface most nearly in accord with the results of astronomical and other observations, made in the progress of the primary triangulation," has received attention, we are informed; but nothing has as yet

been published in regard to it. Whether it will be possible for the Coast Survey to keep up the high standard maintained under Bache's superintendence, remains to be seen. It is fervently to be desired that there shall be no falling off in the execution of a work to which we have been in the habit of looking for important scientific results, which we can hardly expect to get in any other way than through its agency.

The survey of the Lakes, carried on by authority and under the direction of the Department of War, the Coast Survey being attached to the Department of the Treasury, appears to have done its work well so far as the hydrography of our great interior bodies of fresh water are concerned. The work has, however, no great topographical importance, and it ought, for a variety of reasons, to have been executed by the Coast Survey, which, in extending its primary triangulation so as to form a geodetic connection between the Atlantic and the Pacific, might easily have crossed the continent in such a way as to embrace the region of the Great Lakes.

If we have in the Coast Survey a work of which we have some right to be proud, the system of the United States Land Office Surveys, on the other hand, is a very disagreeable subject to handle, since it is marked by the most serious defects, both of plan and execution. Little is known of these matters by the inhabitants of the older States; but in the West the terms "township," "range," and "section" are familiar as household words.

The United States is the owner (nominally at least) of an immense area of land, which has to be surveyed after some fashion before it can be sold or even given away. The Mexican government tried the experiment of giving away land, without defining its boundaries by survey, in California, before that region became United States territory, and the consequence is, that many of the original grantees have been unable to maintain themselves against conflicting claimants, and have lost everything, while multitudes of lawyers have fattened on the spoils, and an amount of fraud has been perpetrated which fairly exceeds belief.

If one looks at an old map of our country, as it was before the Revolutionary War, it will be seen that the States are

divided off from each other on the Atlantic shore and for a little way into the interior, but without any defined boundary to the west. Some States had, as they supposed, claims through to the Pacific Ocean; others extended indefinitely back into the wilderness, so far that the western part was beyond the reach of anybody: that was enough. When Cambridge was laid out, a route for a road was surveyed back into the wilderness for a distance of six miles; that was about as far, they calculated, as civilization would be likely to extend. Of course, when things were so indefinite, there must eventually be a good many conflicting claims. Connecticut, for instance, could not be extended to the Pacific without crossing over New York; so at length, after much discussion, the different States, responding to the appeals of the Revolutionary Congress, New York taking the lead, surrendered their claims to the general government. The United States held no land in any of the original thirteen States, except what was bought for public uses. Vermont was claimed by New Hampshire and New York, but was admitted to the Union as an independent State in 1791. Maine, previously claimed and governed by Massachusetts, was admitted in 1820. Kentucky and Tennessee also came into the Union without giving up any of their lands to the United States; but all the rest of our domain east of the Mississippi, forming the Republic as it existed in 1783, belonged to the general government, and comprehended altogether about 350,000 square miles. By additions since made, namely, by treaty with England, purchase from France, helping ourselves to valuable land belonging to Mexico, and paying her afterwards for worthless, our territory was multiplied sevenfold in area, making seventeen times as much as Prussia had before she commenced the last war, — and not including our last doubtful purchase, Alaska. Not counting that trifling acquisition of 582,000 square miles, we have, or did have, of public land, 1,465,468,800 acres, as estimated, in 1866, at the General Land Office, much of it worthless, and yet including as fine a body of agricultural land as can be found in the world. Nearly all of Indiana, Ohio, and Illinois has already been sold or given away; and, of course, a large quantity in

some of the other States has been disposed of, but a vast amount still remains on hand, although our public lands have been most lavishly given away by Congress, under every sort of pretext. For instance, in 1866, of 4,629,312 acres disposed of, only 388,294 were actually sold; the rest was all got rid of in some way which certainly did not bring any immediate returns of cash into the treasury. It is worth while, then, to learn how this vast body of land is cut up, and its subdivisions so marked that the purchaser may know where the tract to which he has acquired a title is located, — to use a convenient American word, which first came into use in connection with the public land surveys, and which meant originally the selecting of some part of the public domain for a home. It is only after a description of the Land Office system of surveys, that one can form an idea of the geographical value of the work. The area over which these surveys have been extended includes, of course, only land belonging to the United States, as designated above. In the Mississippi Valley and along the borders of the Great Lakes, from Western New York nearly to the western limits of Kansas and Nebraska, the country has almost all been surveyed, and offered for sale or given to railroad and other companies; but farther west there remains still a vast body of land into which the surveys have not been extended, partly for want of time, and partly because the land is not worth enough to make it reasonable to suppose that the amount expended on the work would ever be got back from its sale. Portions have therefore been selected, here and there, and brought into market as required; but there are no large bodies of surveyed land west of the Rocky Mountains, except in the Willamette and San Joaquin and Sacramento valleys.

The object of the United States land surveys is to cut the land up into squares of one mile, which are called sections. This is done by means of the simplest and least accurate instruments, and such as require the least possible amount of skill for their use. The direction of the lines is given by the magnetic or surveyor's compass, and the distances measured with the chain. There is no triangulation or any similar accurate fixing of a net-work of connected points, by means

of which the accumulation of errors is held in check; but the general idea of the methods followed can be given in a few words. If we suppose a line accurately run from south towards the north, or in the opposite direction, all points on that line will have the same longitude. Such a line is run, theoretically, as the beginning of the survey of a certain district, which may embrace a part of a State, or portions of several adjacent ones. The line thus run is called a principal or guide meridian. At right angles to this another line is traced, and called the base line. From the two lines thus established other lines are run and measured with compass and chain, by which the ground is divided off into squares of six miles, called "townships," and these again into subdivisions of one mile square, called "sections," a section containing, "as near as may be," 640 acres. In the centre of each section line a post is set when the line is run, and this is called a "quarter-post," because it answers the purpose of indicating a division of the section into quarters of 160 acres each. By an ingenious system of notation, it is so contrived that any section of land may be easily designated by reference to the number of the meridian to which it belongs, and to its position east or west of that meridian and north or south of the base line. That this system is one very convenient for temporary use, in bringing the public lands into market with the greatest expedition and at the least possible cost, is not to be denied; but what will be the future consequences of the adopting of a method so inaccurate remains to be seen. We have only, at present, to busy ourselves with the geographical material furnished by these surveys. In the first place, the entire unavailability of the system for mountainous regions is to be noticed. The lines cannot be run with a compass and measured with a chain with even a rude approach to accuracy, except in a region which is, at least, moderately level. This is shown by the fact that the townships and sections, in the few cases where the work has been carried into the mountains, have proved, on examination, to be extremely irregular in shape; and it is a fact, that the surveys have been mainly confined to the level strips of land between the ranges, throughout the whole of the mountainous western portion of the country. The system

which answered tolerably for the flat or gently undulating plains of the Mississippi Valley, has been found quite unavailable for the Cordilleras. And, as no topography or hill-shading is given on the plotted sheets of these surveys, no idea of the physical structure of the regions they embrace can be obtained from them, or any map constructed by putting them together, except where the country is destitute of mountain ranges. Of course, as the lines are only run so as to divide the surface into squares of one mile each, all within those squares is a blank, except in so far as it may be deemed reasonable to fill them up by arbitrarily connecting the objects intersected on their borders.

In point of fact, the system of the Land Office Surveys is not only unsatisfactory in itself, but the work has been, much of it, very badly executed. We do not allude here to the defective and even fraudulent character of portions of the less important details, but to those prominent features, the principal meridians, by which the rest of the work is co-ordinated, and which have first to be laid down on the map, whenever Land Office material is to be used for geographical purposes. And it will, we think, excite some surprise after reading in a report of the Commissioner of the General Land Office, the head of this department of the government business, that the guide meridians and standard parallels are "run, *as nearly as human skill can effect it*, upon true meridians and parallels of latitude," * to learn that, in truth, portions of these lines are miles away from where they ought to be, in order that the above statement in regard to the accuracy of the work should be true.† In order that the Land Office work may be utilized at all on any map of the United States which can lay claim to be accurate, the longitudes of all the principal meridians will have to be carefully determined at various points along their course by means of the telegraph. This could be easily done, for the meridians in the valley of the Mississippi, which pass, in good part at

* See Report of the Commissioner of the General Land Office for 1866, Part I. page 8.

† Those who desire to investigate this matter will find it discussed in a chapter of Foster and Whitney's Lake Superior Report, Part II., written by Charles Whittlesey, and also in Warren's Memoir, referred to above.

least, through a thickly inhabited region, intersected by railroads and telegraphs, and of all the geographical work needed at the present time in the country this is the most important. And should the Coast Survey succeed in extending its triangulation across the country, its officers ought to be required to connect their work with the Land Office Surveys, and to establish permanent monuments at suitable points, which should be most carefully protected by legislation, if it be possible in this country to bring about so desirable a result.*

When we come to inquire on what besides the Coast Survey we have depended for the chartography of the eastern Atlantic border, that is, what material has been used in the construction of the maps in common use of the various States from Maine to Georgia, the question is a difficult one to answer; and it becomes a still more perplexing task when we seek to learn what is the relative or absolute value of the material thus used. Chain and compass surveys, either of the towns, the counties, or the States, made for the purpose of fixing their respective boundaries, constitute the principal body of this material; and it has been so long accumulating, that it would be a most tedious and unsatisfactory matter to search out the history of these fragmentary undertakings. Indeed, this could only be done under the authority of the various States, and with diligent investigation of their archives. Discrepancies of several miles are believed, with good reason, to exist in the boundaries of some of the States; and the recent re-examination of the line between two of them — New York and New Jersey — has shown very clearly how full of errors the old compass surveys were, even when best done. The only States which have undertaken any systematic surveys, for the purpose of securing correct maps of their territory, are New Jersey, Pennsylvania, and Massachusetts, and in no one of these instances has the result been satisfactory. New

* There is something truly alarming in the thought that the lines of the United States Land Office Surveys can never be run over again, or their location be re-established, after the marks by which the work is indicated on the surface have been obliterated. And these marks are only small wooden posts, mounds of earth, or "blazes" on trees, none of which can survive many years, while most of them disappear very quickly, unless some one has a special motive for their preservation.

Jersey made a very creditable beginning, having an excellent basis in the Coast Survey triangulation, which, from the peculiar form of this State, extends over no small portion of its area. The work, begun in 1854, was carried on for two or three years and then suspended, although a good deal of valuable material was collected which was afterwards utilized in the State geological map. A large amount of topographical work was done in Pennsylvania, in connection with the State Geological Survey, in the way of improving the map of that State; but there was no accurate triangulation made, neither was the topographical map which was constructed ever laid before the public, although it was used to some extent in the geological atlas accompanying the final report by H. D. Rogers.

Massachusetts was, however, the first to institute what was intended as a topographical survey, but which really turned out to be only a triangulation, bearing the same relation to a finished survey that a skeleton does to the living body. It will be worth while to look a little more closely into this matter, and to set forth the errors into which the Legislature fell from entire ignorance of the subject. This ignorance was, perhaps, not so blameworthy forty-five years ago, but it would be inexcusable for the State to enter on another work of this kind, without more knowledge of what is needed, and of how such a survey should be executed, than existed in this community when the former survey was instituted.*

In 1829 a committee was appointed by the Legislature of Massachusetts to take into consideration the subject of "procuring such a map or such maps of the Commonwealth as the public good requires"; and in the following year this committee reported that "a good map, projected on a large scale, from actual surveys," was much needed. The old map of the State, made in 1801, "from authentic sources," and the surveys for which had been ordered by the Legislature in 1794, was no longer sufficient. The idea of a topographical survey and map seems to have been rather mixed up in the minds of

* Yet at the very time the Massachusetts Survey was going on, Bessel and Baeyer were doing the most exquisitely accurate geodetic work in Prussia, not to speak of the Ordnance Surveys of England, France, and other European countries.

this committee with that of a census and gazetteer; for in their report they state that, as a new census of the United States has to be made in 1830, as well as a new valuation of the States, "a great mass of appropriate information could be obtained free of expense." The committee did, however, see the necessity of a survey "on trigonometrical principles," and they thought that the work could be done "by some scientific gentleman," in one season, with such assistance as would be derived from information already on hand. If such a survey could be made, another one would never be needed; but it is modestly added that "a small appropriation for this purpose would be required." The idea was, that each town should make its own chain and compass survey. "Such a survey could be made by the selectmen," as the report has it, and the material thus acquired was to be put together on trigonometrical principles by the "scientific gentleman" employed to superintend the work. The engraving and printing, it was thought, could be paid for from the proceeds of the sale of the map. The action of the Legislature was in accordance with the above-cited recommendations of the committee; an appropriation of $2,000 was made to carry on the work, and the towns and cities of the Commonwealth were required, under a penalty for non-compliance of $100, to have minute and accurate surveys of their respective territories made within a year, and the State surveyor was to "project an accurate skeleton plan of the State," which should "exhibit the external lines thereof, and the most prominent objects within those lines, and their locations."

The triangulation was mainly executed by Mr. Simeon Borden and completed in 1839, with a higher degree of accuracy than was to have been expected under the circumstances, and in a manner very creditable to Mr. Borden's ability and perseverance. The astronomical portion of the survey was under the direction of Mr. R. T. Paine, and small portable instruments were employed, namely, the sextant, or reflecting circle,* and a number of chronometers. The precise object for which these astronomical observations were made, it is not easy to under-

* The name of the instrument is not given in Mr. Paine's report of his operations; it is simply called "a reflecting instrument."

stand, as it is not likely that they were ever used in rectifying the triangulation, which was of a higher order of accuracy than the astronomical work. When, however, the chain and compass surveys, made by the selectmen or their agents, came to be fitted into the main triangulation, — which should have been supplemented by a secondary series of triangles, so as to largely increase the number of points established, — there was much trouble, as might have been expected. It was an attempt to reconcile data of a very uncertain character; indeed it was a most thankless job, and the result was not satisfactory, falling far behind what had been expected, although the work had occupied thirteen or fourteen years, instead of the one year it was expected to take when commenced. The map as finished was on too small a scale — two and a half miles to the inch — to be of much use as a town or county map, and of course of no service as marking the lines or divisions between the estates of private parties. It was also very defective in respect to its exhibition of the character and relief of the surface, this being an item in the requisites of a good map not at all appreciated in this country at that time. A new edition was issued some years afterwards, on which an attempt was made to improve the hill-shading, which, however, was still very unsatisfactory.

Maps of several of the counties and towns of Massachusetts and New York, and probably of some other States, have from time to time been prepared and issued by private parties, who appear to have found the business profitable. The surveys for the county work appear to have been made by driving over the roads with an odometer attached to a wheel of the vehicle used, thus determining the distances with some approach to accuracy, while the pocket compass was probably chiefly relied on for direction. The names of the occupants of the houses are given, and small plans of the principal towns figure on the borders of these maps. Chartographic work of this kind is very defective, especially in the way of hill-shading; but it is better than nothing at all; and the fact that such maps can be made and sold with profit indicates very clearly how strongly the want of good ones is felt by the people. The books of city maps furnished by private enterprise are more satisfactory than

the county maps, but still far from being complete, and they especially lack the stamp of "official" upon them, so that they cannot be used where permanency and the law are to be taken into consideration.

From what has been said above, it will be readily gathered that we have very poor local maps of the Eastern States, and no good general one. One would suppose that the grand chain of the Appalachians, situated as it is in the midst of a civilized nation, would be well known to us even in the details of its remarkable and beautiful physical structure. This, however, is not the case; and if it is no longer true, as Guyot said in 1861, that it is "one of the chains of which we have the least amount of positive knowledge," it is chiefly due to the persevering and unremunerated labors of that distinguished geographer, during a decade of years, that we have now even a general idea of the character of this chain. Professor Guyot's investigations have had reference rather to the previously entirely unknown altitudes of different portions of the Appalachian range than to its structure; what we know of the latter is more to be gathered from his published verbal descriptions than from the accompanying map, which is on so very small a scale (1: 6,000,000) as to be, in fact, only a sketch.

Professor Lesley, who was the principal topographical assistant on the first geological survey of Pennsylvania, has also interested himself much in regard to the structure of the Appalachians, and even prepared a large map intended to illustrate the peculiar features of different portions of the range; this was, however, never published, although a part of it was photolithographed, as an illustration of a paper in which the typical topographic forms of this remarkable chain were discussed.

The deficiency of our knowledge of Appalachian topography may be, in part, excused, it is true, by the difficulty of surveying an intricate region of ridges of nearly uniform elevation, and densely covered with forests, which impede the vision, and thus render it impossible to work with rapidity; but the real trouble is, that the people have not yet been educated up to the point of fully appreciating the scientific interest as well as the practical value of accurate geographical and topographical work.

Mention should be made of the fact, that, during the War

of the Rebellion, a considerable amount of topographical material was obtained, through the assistance of the Coast Survey chiefly, in parts of Tennessee, Kentucky, Virginia, and other States which were then the seat of war. The need of the kind of information which only an accurate and detailed survey can give was keenly felt at the time our armies were moving over the *terra incognita* of the western slopes of the Appalachians, and it was hoped that the impetus given to this kind of work at that time would continue to be felt after the war was ended, and that the result would be, that under the lead of the older and richer States, the work of mapping the Atlantic border of the continent would be seriously taken in hand. Nothing has been done, however, and we remain apparently very much in the same condition as to geographical progress that we were in ten years ago. This is the case, at least, with regard to action on the part of individual States; but the United States has taken several steps in advance, some of them very curious ones, as will be seen further on.

The United States Engineer Bureau has received from Congress large sums of money for many years back, nominally for "surveys for military defences." A considerable portion of this has been used for the topographical reconnoissances referred to on previous pages, and for many other similar and less important ones. The total amount thus expended it would be quite impossible for one outside of the bureau to state; but it must have been very large, probably not less than $100,000 a year, on the average. Previous to 1867 no system of surveys had been inaugurated, and but little if any work done of a permanently valuable character. The determinations of distances were almost exclusively dependent on estimates of the pace of the horse or mule ridden, and the astronomical observations by which the work was checked were extremely unreliable. This is well illustrated by reference to Lieutenant Simpson's work in the Great Basin. His longitude of Genoa, one of his three principal astronomical stations, where a series of observations of lunar culminations was made, appears now from the telegraphic determination of the position of the 120th meridian by the Coast Survey, to have been over eight miles out of the way. And in further

illustration of this, it may be stated, that on comparison and reduction to one scale of all the work done in the Great Basin by the United States Engineer officers, previous to 1867, by the writer of this article, it was found that no portion of it could be used for a general map of Nevada even on a small scale; indeed, the discrepancies of longitude and vagueness of the topography were so great on all the published maps of the War Department and Engineer Bureau, that no one chain of mountains, between the Sierra Nevada and the Wahsatch, could be identified as being the same with any range on the carefully surveyed map of Butler Ives, spoken of above, and which proved, on repetition of the work by the Fortieth Parallel Survey, to be remarkably accurate in its general delineations of the mountain masses, although in part deficient in detail.

In 1867 the Fortieth Parallel Survey was instituted by Congress, and the work placed nominally under the direction of the Bureau of Engineers, but in reality given to a civilian, Mr. Clarence King, who had as his principal topographical assistant Mr. J. T. Gardner, both of these gentlemen having been previously connected with the Geological Survey of California. Under Mr. King's direction, a belt of country over a hundred miles wide and extending from the western borders of Nevada to the eastern base of the Rocky Mountains was topographically and geologically surveyed with a much higher degree of precision than had ever before been attained in that region. The whole area was carefully triangulated, and the work checked by accurate telegraphic determinations of longitude at suitable points, as well as frequent observations for latitude with the zenith telescope. For the geographical map, which is comprised in ten sheets, on a scale of four miles to an inch, the hill-shading has been carefully and beautifully executed with the brush, and copied in crayon-work on stone. The geological work will be exhibited on contoured sheets, the curves being drawn at vertical distances of four hundred feet. Thus picturesque effect is combined with accurate delineation of the vertical element, so far as is practicable on the small scale necessarily adopted in the survey of so vast a region. This work is nearly ready for publication.

The success of the Fortieth Parallel Survey and the gen-

erally recognized value of the work led the Department of the Interior to inquire whether they also could not do something in the way of more accurate topography on the western side of the continent. A geological survey had been going on for some time, in the Territories of the United States, and under control of the Secretary of the Interior, but having no connection with the General Land Office, which is another branch of that department. This geological work, having no geographical basis, was of little value, except as a rough preliminary reconnoissance. To remedy this difficulty, it was proposed, in 1870, that a topographical corps be added to the geological, and, the sanction of Congress having been obtained, this was done. The remodelled survey was then known as the "United States Geological and Geographical Survey of the Territories," and the topographical portion of the work was placed in charge of Mr. Gardner, the principal triangulation of the Fortieth Parallel Survey having at that time just been completed. For the continuation of this work Congress has made liberal appropriations at the two last sessions, $95,000 having been granted for the present year. The work thus far has been mainly confined to Colorado, and a map of that recently admitted State, in six sheets, is said to be in preparation. It is in the area which lies between the meridians of 104° and 110° and is included between the parallels of 36° and 39°, that the survey is to be prosecuted during the season of 1875. This embraces Southern and Southwestern Colorado and the northern part of New Mexico. Of the scale or style adopted for publication in this work no information has been received. A preliminary sketch showing the progress of the triangulation in Central Colorado, on a scale of eight miles to the inch, is appended to the report of progress for 1873; and a description of the method adopted for measuring the base line, and of the system pursued in the triangulation, is also added. From what has been published it may be inferred that this work will not fall short of that of the Fortieth Parallel Survey in accuracy, and that it will be of a much higher grade than any of the previous reconnoissance maps of the United States Engineer Bureau, in the region west of the Rocky Mountains.

Mention should here be made of a survey of the Colorado

River, which has been going on for about five years, first under the direction of the Secretary of the Interior, and afterwards under that of the Smithsonian Institution. This survey, which is in charge of a civilian, Mr. Powell, had cost, up to the end of June, 1874, about $62,000, and a liberal appropriation was made in addition by the last Congress for its completion. From Mr. Powell's statement, submitted last year to a committee of Congress, it appears that an area of 45,000 square miles of territory about the head and along the course of the Colorado River had been explored and surveyed by his party. This region is an exceedingly difficult one to map, being much cut up with deep gorges and cañons, and very dry, as well as distant from any practicable base of supplies. It is understood that this survey has been in part based upon a triangulation; but nothing has been published as yet from which any opinion can be had with reference to the style and accuracy of the work. It was probably admiration of Mr. Powell's pluck and endurance, as manifested in his at first almost unaided exploration of the cañon of the Colorado, which led Congress to encourage and adopt the work, rather than a knowledge of his having had any scientific training or peculiar fitness to be at the head of a topographical or geological survey.

The two surveys just spoken of, as will be evident, are duplicates of each other, since to a certain extent there does not appear to be any limit fixed to either of them by Congress so that they shall be prevented from overlapping. The term "survey of the Territories" is, of course, an unmeaning one, since that which was a Territory to-day may be a State to-morrow. Thus Colorado, in which most of the topographical work under Mr. Gardner's direction has thus far been done, is now within the Union, although only a Territory when the survey was begun. A survey of the Colorado River might, on the other hand, without any impropriety, be made to cover all or nearly all of Arizona, Colorado, Utah, and Wyoming, since all these are largely drained by the Colorado and its tributaries. Thus we have two independent geological and geographical surveys over an area of not much less than a quarter of a million of square miles west of the crest of the Rocky Mountains, and it will be noticed that these are both under the

control of the Secretary of the Interior, one of them directly and the other indirectly, yet both supported by special grants from Congress. This may appear to be a singular arrangement; but the reader will be surprised to learn that a third geological and geographical survey of the same area is also in progress, under the direction of the Engineer Bureau of the Department of War. This work is usually known as "Wheeler's Survey," having been in charge of a United States engineer officer of that name. It was begun in 1869, and last year the first number of an atlas was issued which gives an idea of the general plan and execution of the work.

According to an outline sketch in the atlas, the whole region west of the one hundredth meridian is to be represented on ninety-four sheets, each eighteen by fifteen inches in size, and on a scale of eight miles to an inch (1 : 506,880); of these four are given in the first number, and these cover very much the same ground which is intended to be embraced in Mr. Powell's map. Thus far the field-work of Wheeler's Survey has been almost exclusively carried on in the same region in which Messrs. Powell and Gardner have been employed, and it is evident that this has not been done without design. It has been, and probably still is, the wish of the Engineer Bureau to put a stop to all topographical work done in the region west of the one hundredth meridian, except such as may be under their own direction. It has been for the purpose of forcing this issue, that the region in question has been divided off as mentioned, and that particular region selected for exploration which others were already engaged in mapping. Indeed, the matter has already been up before a committee of Congress, and a very unpleasant altercation had between the officers and employees of the War Department on one side and of the Interior on the other.* Those who wish to investigate the subject can find material for doing so in the documents to which reference is made in the foot-note. In point of fact, no good has been accomplished by the Congressional investigation; the work is still going on exactly as before. Instead of a careful and systematic consolidation of all the United States geograph-

* See House Report, No. 612, 43d Congress, first session; also Senate Report, No. 311, same session, and House Executive Document, No. 240.

ical and geological work in the Far West, under one supervision, in one department, there is just that method employed which leads to bad results and great waste of money. Congress is at this moment paying to have the same work done, on the same ground, by two, if not three, different parties, and in two different departments. At the investigation referred to above, the influence of the most eminent scientific men throughout the country was exerted in favor of the continuance of the geographical surveys begun by Mr. Gardner under the direction of the Secretary of the Interior. This was done because, as was clearly shown before the committee, the four maps issued by the Engineer Bureau, as a first instalment of the "Geographical Explorations and Surveys West of the One-hundredth Meridian" were so defective and so far inferior to the work of the "Fortieth Parallel Survey," that it seemed inconceivable that, when the public attention was called to the fact, the poorer work should not be stopped and the better allowed to proceed. Instead of this, liberal appropriations were made for both classes by Congress, this year as well as the last, and how long this condition of things will be allowed to continue no one can foresee. To those who, like the writer of this article, earnestly desire to see the geography and geology of the Far West carefully and economically worked out, and who know what a tedious and costly job it must be, even when most economically and conscientiously carried on, the present state of things is indeed disheartening. It shows, perhaps as well as anything can, the defects of our system of managing public affairs, if system that can be called which has no other basis than the whim of a Congressional committee, or the tact and persistency of some individual who has a private object to gain, and who for this purpose seeks a position for which he is neither fitted by education nor by natural gifts.

It is something for which to be thankful that the opposition of the Engineer Bureau has not succeeded in wiping out the appropriations made for the extension of the Coast Survey triangulation through the interior. And yet the amount given for this purpose, thus far, is hardly more than a nominal one. Even if the whole sum were confined in its expenditure to a single State, it would not be more than enough to push

the main triangulation in that one with even a moderate degree of rapidity. This may easily be inferred from the fact that, although the Coast Survey has been going on for about twenty-five years on the Pacific side of the continent, the main triangulation along the coast line, forming the basis of the hydrography, is very far from being finished; one would say from a glance at the progress-sketch published in the Report for 1870, that it was not by any means half done, and this, of course, without including Alaska. Yet the amount appropriated for the work on that coast seems to have been quite large, since it was, for the year 1870–71, $200,000, while $275,000 was asked for its continuance in 1871–72.

We have thus reviewed the sources of chartographic information in the United States at the present time, and endeavored to show, to the best of our ability within the limited space available, what has been done and what is now doing in the way of gathering the materials for the complete elucidation of the geography of this vast country. We have next to turn our attention to surveys which are designated as "geological," and to show what their object is, and what progress they have made in different parts of the world, and especially within our own borders. We shall then be prepared to discuss, somewhat more in detail than has yet been done, the character of the topographical and geological work needed by that one of the United States which is most densely populated and wealthiest in proportion to its area. In doing this we shall have occasion to examine and criticise the official report presented to the Legislature in November last by the committee appointed "to inquire into the expediency of a new survey of Massachusetts."

J. D. WHITNEY.